DEVELOPMENT OF INQUIRI-BASED LEARNING DEVICES FOR TRAINING STUDENTS' SCIENCE PROCESS ON MATERIAL ELASTICITY

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Abstract: This study aims to produce an inquiry-based physics learning device to train high school students science process skills on the subject of material elasticity. The research design uses Kemp model tested in three classes of class XI MIA- 1 , class XI MIA- 2 , and class XI MIA- 6 with total number of students of 90 in SMA Negeri 5 Ambon, second semester of academic year 2017/201 8. Group pretest-posttest design was used for test design. Data analysis techniques used include, 1) Qualitative descriptive analysis including validation result, readability level, Lesson plan implementation, students' activity, learning constraints, science process skill result , and response. 2) Parametric statistical analysis includes: normality test, homogeneity test, and t-test. Finding showed that, 1) validity of learning tools developed is categorized as valid ; 2) the effectiveness of instructional tools in terms of: (a) the attainment of science process skills in the three classes obtained a significant increase in science process skill on each indicator studied by the researcher; (b) The student's response to the device and the learning implementation is very positive with the highest percentage is with teacher guidance when working on worksheet. Based on the finding, physics learning device by using inquiry model to train the students' science process skill which has been developed has met the criteria of validity, practicality, and effectiveness that it is feasible to be used to train students' science process skills on materials elasticity.

Key Words: science process skills, inquiry learning model

INTRODUCTION

Science and technology are increasingly advanced today and is inseparable from findings in the field of science. The rapid technological advancement requires teachers to work harder because teachers are not just passing information but teachers should be able to teach and instill how to solve problems for students to develop and compete and answer future challenges. The development of student problem solving skills is not easy but requires special skills called process skills. Process skills can be defined as models of knowledge, social and physical skills derived from fundamental abilities that are principally present in the student (Dimyati, 2002). These basic skills are often called science process skill.

Carin (1993) states that "Knowing science is more than knowing content, it is also knowing how to gather evidence and how to relate evidence to interpretation". Science learning does not merely memorize knowledge but also involves a process of seeking knowledge that is accompanied by the ability to think in order to link evidence of knowledge acquisition. Science includes three areas namely scientific knowledge, scientific processes, and scientific attitudes. This scientific process is often called the science process skills.

According to Setiawan (1992) science process skills are physical skills to acquire and develop facts or scientific processes on their own and improve and develop the character and values demanded. There are several reasons for the need for a process skill approach in the process of teaching and learning in science (Dimyati, 2002): (1) process skills approach gives learners the accurate meaning of the nature of science. Students do not only know knowledge but can also understand and interpret facts and concepts from science.(2) teaching this means the teacher gives the students the opportunity to find a knowledge, so that not only the teacher tells the science. (3) the use of this model to teach science trains students to learn based on the processes and products of science at once, thus, physics learning which tends to be monotonous with low science activity can be overcome by a process skill, where the process skill encourages students gaining better knowledge than simply listening to the teacher's exposure (Suwasono, 2011).

Based on the observations at SMA Negeri 5 Ambon, the lesson was conducted monotonously with the absence of simple practice in physics and teacher develop learning tool partially. In this case, the science skill process was developed in reference to the content standards, yet the student manuals and books generally refer to the existing package of publications.

The reality in the field shows the result of final exam marks of SMAN 5 Ambon students was low. This is based on data from Ministry of National Examination results of 2017 showing the average score for material elasticity and Hooke Law was 35.67. The data shows that the average of final exam marks was far below the average compared with other schools. In addition, students' ability in solving daily Deuteronomy problems for material elasticity of the academic year 2016/2017 was also low with many students' score was under the KKM (minimum score), only 25% of students scored above the KKM set by 66.

The results of the TIMSS and PISA studies above show that the ability of Indonesian students to think high level is still relatively low. Students have not been able to work on questions to think higher or known as High Order Thinking. Higher thinking abilities are in the skills of the science process. The data obtained for each science process skill indicator in SMAN 5 Ambon include (1) formulating problem 0%, (2) formulating hypothesis 0%, (3) determining variable 0%, (4) interpreting 0% 5) concluding 0%. The data indicate that in SMAN 5 Ambon does not train students' science process skills. Meanwhile, problems on international level such as PISA and TIMSS include the elements of science process skills.

The low skills of the science process are also supported by previous research. According to Aktamis, et al (2008), Indonesia can only recognize the basic facts of knowledge but cannot communicate that knowledge through the invention of science nor apply the concept in a complex and abstract skill. Indonesian students are on average only able to remember knowledge through the application of formulas in solving academic problems while the science process skill is still low. Therefore, it is necessary to improve or optimize the skills of the science process.

In order for process skills can be achieved optimally, inquiry learning model is necessary. The word Inquiry means involvement in asking questions, finding and conducting investigations. Inquiry learning (self-learning) is one of the right models to help students to more actively discovery and spur the ability to think. Inquiry model is a model of putting a scientific appraisal. Through inquiry learning students can think systematically, logically and critically, and can improve intellectual ability that is part of the mental process (Sanjaya, 2006). In inquiry learning, the teacher is merely a facilitator rather than a teacher, so using this model the teacher can encourage students to develop the schema formed in students' thinking and provide a learning environment that fosters student activity. Application of inquiry in the process of teaching and learning to train the skills of the process of science requires appropriate learning device.

Appropriate equipment needs to be prepared by teachers because the lack of process skills and understanding of physics concepts depends not only on the inability of students to receive lessons, but also influenced by the teacher's ability to manage learning activities and the tools used (Taufiq, 2014). Therefore it is necessary to develop a learning device to apply a model that involves learners in the learning activities that inquiry. Students' involvement in scientific inquiry is an important component of science instruction that helps students develop science literacy and gives them the opportunity to practice important science process skills in addition to critical thinking and problem-solving skills (Khishfe and Abd-El-Khalick, 2002). The title taken by the researcher is:
"Development of Inquiry-Based Physics Learning Devices to train Science Process Skills of High School Students on the Subject of Material Elasticity".

METHOD

This research is classified as development research FOR the researcher develops physics learning device by using inquiry model to train the science process skill of SMA students on the subject of material elasticity. This development study refers to the model developed by Kemp, et al (1994). Learning tools developed include lesson plan, worksheet, BAS, and evaluation instruments.

Subjects in trial II are instructional tools using inquiry developed and tested in grade XI students of SMAN 5 Ambon even semester of academic year 2017/2018. In the second trial involved 30 students in 3 classes.

The test of the device was performed by using one group pretest-posttest design because it uses one group without any comparison group. The device test is carried out to see the characteristics of the students. This design is written as follows (Prabowo, 2011):

$$U_1 \longrightarrow L \longrightarrow U_2$$
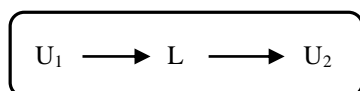
Where:
U_1: pretest to review the student's Science Process Skill before being taught with an inquiry model;
U_2: posttest for to find students' science process skill after being taught with inquiry learning model.
L : learning by using inquiry model.
The design of Inquiry model learning device development using a simple tool is described with a flowchart on figure 1.

Method of collecting data

This method is used to check the relevance and accuracy of data, and can be used with the appropriate composition in accordance with the objectives of the study. The methods used in this trial include, 1) validation data ; 2) readability level data ; 3) observation data ; 4) Science Process Skkill data ; and 5) students' response data.

Data analysis technique

Data analysis in trial II was performed by using quantitative descriptive analysis to describe data as it is in percentage form and explain the data or events with qualitative elicitation phrase which include:

1) Learning Device Validity Analysis

Data analysis of device validity is carried out by averaging each score obtained from every aspect assessed by the validator. The average score of each aspect is then categorized based on Ratumanan and Laurens (2011).

2) Analysis of BAS and worksheet readability

The validity data obtained was analyzed by quantitative descriptive technique. The result of this data is elaborated with qualitative descriptive technique. The level of legibility is calculated by comparing the number of words correctly filled with the total number of words that should be filled 100% times. Calculation of legibility uses the following formula:

$$K_B = \frac{k}{\sum k} \times 100\% \qquad (1)$$

Where
K_B = level of legibility
k = words read by the students
$\sum k$ = total word to be filled by the students

3) Analysis of learning implementation

Assessment by observer was conducted on the implementation at opening, core activities, closing, time management, and classroom situation. Technique used to analyze a data result of observation is descriptive quantitative, result of analysis is elaborated by using qualitative descriptive analysis. Criteria of learning implementation are performed based on Riduwan (2012).

4) Analysis of Student Activity

Student activity is all activities undertaken by students during teaching and learning activities took place and assessed by two observers. To analyze the observed student activity, percentage technique (%) is used, i.e the number of activity frequency that appears divided by the whole activity multiplied by

100%. The equation (Arifin, 2010) is written as follows.

$$P = \frac{\sum R}{\sum N} \times 100\% \qquad (2)$$

Where:

P : percentage of student activity

$\sum R$: the number of student activities that appear

$\sum N$: overall student activity

5) Analysis of Learning Constraints

Constraints are analyzed with qualitative descriptive i.e observers and researchers provide notes about the barriers that occur during teaching and learning activities.

6) Analysis of Science Process Skills of Science

The result of the student's assessment is obtained by using test method. Based on Permendikbud No 23 of 2016, skills assessment is an activity conducted by participants to measure the ability to apply the knowledge acquired and perform various tasks. Comprehension value of competency of knowledge and skill aspect is poured in the form of number with scale 0 - 100. Aspect of skill in SMAN 5 Ambon is complete if fulfill the predefined minimum score by 66 (C). The effect of learning on students' science process skills was measured using a normalized gain analysis adapted from the normalized gain formula (Hake, 1999).

$$< g > = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{100 - \langle S_{pre} \rangle} \qquad (3)$$

where:

$<g>$ = Improved learning outcomes (average normalized gain)

$<S_{pre}>$ = Average pretest value

$<S_{post}>$ = Average posttest value

7) Analysis of Students' Responses

Questionnaire of student responses is used to view students 'opinions about the learning model that is taught to train students' KPS. Student responses are analyzed descriptively with the percentages can be written as follows (Riduwan, 2012).

$$P = \frac{\sum Y}{\sum K} \times 100\% \qquad (4)$$

where:

P = Percentage of student opinion scores

$\sum Y$ = number of learners who choose the answer

$\sum K$ = the number of all learners

8) Statistic analysis

a. Normality test

Normality test aims to know whether the sample data obtained normally or abnormally distributed. Normality tests were performed on pretest data with the assumption that before being given the same treatment in each class XI MIA-1, class XI MIA-2, and class XI MIA-6, normalized data is analyzed. If the normal test results show the data of each class is normally distributed, then it can be given the same treatment in each class XI MIA-1, class XI MIA-2, and class XI MIA-6. Normal data can be determined using some statistical tests, but in this study only use Kolmogorov Smirnov test with significance level $\alpha = 0.05$ (2- tailed). Hypothesis form for normality test according to Sugiyono (2014) is:

H_0 : data comes from normally distributed populations.

H_1: the data come from not normally distributed populations.

If Sig $< \alpha$, then H_0 is rejected.

If Sig$>> \alpha$, then H_1 is accepted.

b. Homogeneity Test

Homogeneity testing is a test to see the equality between one sample and another sample in one population. Homogeneity test used in this research is Levene test with significance level of $\alpha = 0.05$ (2- tailed) hypothesis testing according to Sugiyono (2014) are:

H_0 : data comes from the same population variance.

H_1 : the data comes from an unequal population variance.

If Sig. $< \alpha$, then $H_{0 I}$ is rejected

If Sig. $> \alpha$, then $H_{0 is}$ is accepted.

c. Test-t

The t-test used in this study is a paired t-test (Paired Samples t Test) to compare two paired samples. Paired samples are defined as a sample of the same subject, but subject to different treatment. For example, prior to receiving treatment, XI MIA-1 received pretest (pretest as data prior to treatment). Posttest is conducted after treatment (posttest as data after treatment). This cycle is also applicable for class XI MIA-2 and XI MIA-6. Paired t-test should meet some of the assumption prerequisites that the sample data is normally distributed and the sample data is homogeneous. The paired t-test uses n-1 free degrees, where n is the number of samples and the significance level $\alpha = 0.05$ (2- tailed). The hypothesis for t-test according to Sugiyono (2014) is:

H_0 : The average pretest and posttest results are no different.

H_1 : The average pretest and posttest results are different.

If Sig$> \alpha$, then $H_{0 is}$ is accepted.

If Sig $< \alpha$, then $H_{0 is}$ is rejected.

RESULT AND DISCUSSION

A. Device Learning Validation

In a process of learning, the development of learning tools is needed in order to support the implementation and improve the learning process to be implemented. Stages of instructional devices conducted in this study using Kemp model.

The reason for adopting Kemp model is because the steps in this development model are more systematic, making it easier to perform the device development process.

The development of physics -based inquiry tools is valid if it meets the minimum validity score of 2.6 (Ratumanan and Lauren, 2011) to train high school students' KPS on the subject of material elasticity. The result of development of learning tools include RPP, BAS, LKS, and test questions SPS can be found in the Figure 2.
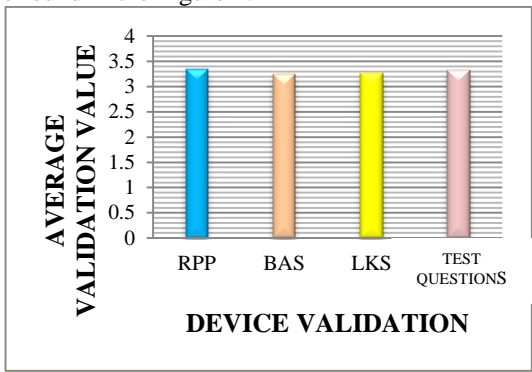

Figure 2. Results of Validation of physics learning devices.

The achievement of valid categories in the development of learning tools with development is through several stages of needs analysis, student characteristics analysis, concept analysis, task analysis, discussion with high school physics teachers, supervisor study, and input the three validators so that learning tools that have been developed can be used in learning physics to train student KPS on the subject of material elasticity.

Learning development steps take into account the characteristics of the mode l used. Researchers to use it's a development model learning device according to Kemp (1994), which includes problems in learning, analysis of the characteristics of learners, task analysis, formulating learning goals, learning strategies, selecting instructional media, election support services, preparation of evaluation instruments, and validation learning Media. Development of learning tools that researchers develop includes RPP, BAS, worksheet, and evaluation instruments. The development of learning tools developed by researchers has been validated by some validators who are competent in the field of physics education and have been declared invalid so that learning tools developed can be used for research.

B. Practicality Learner's Devices

The practicality of instructional tools can be obtained from the results of legibility of learning devices, the results of implementation of lesson plan, the results of student activities and constraints faced.

1) Readability of instructional devices

Readability is a number of elements that exist in the text that affect the success achieved by the group of readers. Readability can be interpreted as matching the ability of one's understanding of the material discourse written at a certain level (Taylor, 1953, Gilliand, 1976). The legibility sheet of BAS and worksheet devices is arranged in the form of a reading instrument from BAS and LKS which has been systematically omitted certain words every 5th word. The answers from students can be read well if the answers in the complete paragraph are true and the overall device legibility is a total percent of the total correct student responses. The results of BAS and LKS readability can be seen in Figure 3.
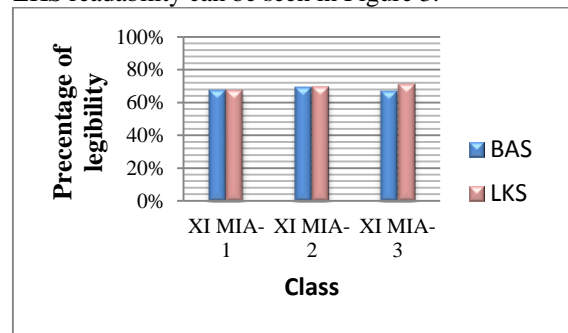

Figure 3. Results of legibility of physics learning devices

Readability of BAS device with 40 parts of keywords removed and worksheet readability with 30 parts of keywords eliminated was obtained. In class XI MIA-1 BAS readability was 67.42% and worksheet was 67.11%, readability of BAS in class XI MIA-2 was 69.42% and 68.89% for worksheet. In class XI MIA-6 BAS readability was 71% and worksheet readability was 66.56%. They fell in moderate level which means the level is quiet easy to understand by most students. Readability is difficult in low readability. Low readability means it can only be understood by a small number of students (Taylor, 1953; Gilliliand, 1976; and Harjasujana, 1998).

2) Implementation of lesson plan

Assessment of the implementation of the stages contained in the lesson plan is done during the

learning process takes place by two observers who are physics teachers in SMA Negeri 5 Ambon. Criteria of the stages are the quality of the implementation of stages with a score of 1-4. The results of lesson plan implementation is shown in Figure 4, Figure 5, and Figure 6.
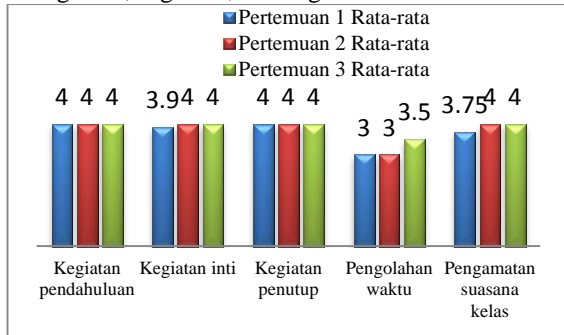

Figure 4. Results of the implementation of physics learning device in class X I MIA- 1
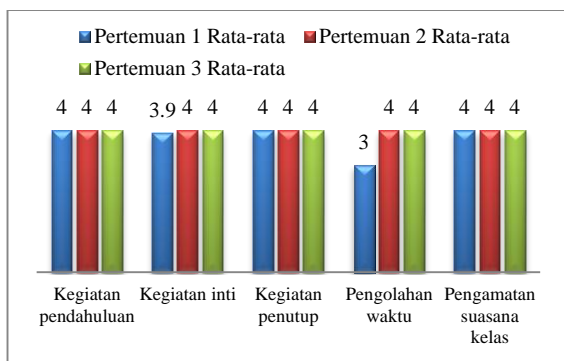

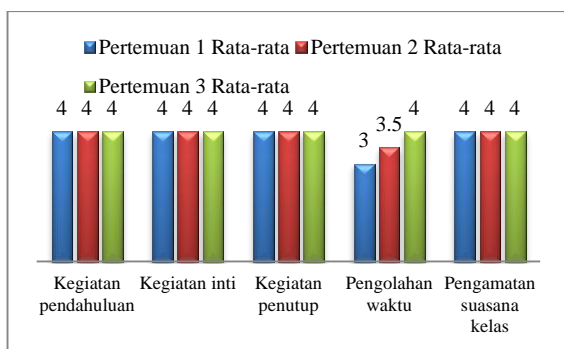Figure 5.   The results of the implementation of physics learning device class X I MIA- 2

Figure 6.   The results of the implementation of physics learning device class X I MIA- 6

The results of the three classes indicate that the teacher has implemented the stages contained in the lesson plan, this is because before conducting trial II, the researcher has several times read and reviewed the lesson plan that has been prepared so that the stages in the lesson plan can be performed well. In addition, at the time of trial the II researchers always bring the lesson plan that has been compiled and read the stages that must be implemented at that time, so

no stages are forgotten, only at the first meeting of the aspects that are not well implemented is the processing time, this because the researcher did not set the time at the time the student experiments, so the students tend to spend a lot of time at the stage of experimenting. However, at the second and third meeting the researcher has known the time set according to the input of the observers, so that the implementation of the lesson plan is performed well.

The implementation of good lesson plan is demonstrated by the improvement of science process skills. If the teacher has implemented the learning steps contained in the RPP well then obtained a satisfactory learning outcomes. This is in line with the opinion expressed by Ivor K. Davies (in Suyono, 2011) that one of the roles and functions of the teacher is as a culminate, the teacher designs the lesson from beginning to end from simple to complex, the students reach the culmination of success in teaching and learning process.

3) Students' Activities

Students' activity is measured using the students' activity observation sheet instrument. Students' activities observed include observing teachers explaining, observing demonstrations, formulating problems, formulating hypotheses, identifying variables, conducting experiments, collecting experimental data, analyzing experimental data, discussing with group mates, drawing conclusions, presenting the results of the experiments, and providing inserts. The students' activity of the two observers in each of the most prominent meetings is the experimental activity.

The activity is in accordance with the lesson plan activities based on the inquiry learning model to train students' science process skills. The inquiry model emphasizes maximum student activity to seek and find, meaning that inquiry strategies place the students as subject of learning. This is in line with Nur's (2002) opinion of the skills of the science process, that is, the skills students learn when they are actively involved in scientific investigation through asking and answering a question, and they use a variety of science process skills.

There are still irrelevant activities in the lesson implementation; it indicates that there is still a lack of inquiry learning to train the science process skills in the learning process. The shortages has been minimized as small as, because every time done learning, researchers who act as teachers and two observers to evaluate together to improve the deficiencies that exist so that the next meeting to be better.

4)   Obstacles

During teaching and learning activities, there are constraints in the learning process. Constraints during the learning process are seen by two observers and after learning activities are completed given alternative solutions. The constraints and alternative solution given by two observers that is for the first meeting, students did not know to formulate the problem, create a hypothesis, and determine the research variables, so the alternative solution is to explain more slowly definition of the variable, then explain the three variables, and guiding students more slowly in formulating problems, formulating hypotheses, and defining variables. In the second meeting, the students were lack of understanding of the experimental steps and did not know the name of the tools and materials used, so the alternative solution was to clearly and slowly explain the steps of experiment and demonstrate the tools and materials slowly. In the third meeting, experiment III is a little complicated to do so it needs more guidance and explanation from the researcher, while the alternative solution is to provide more intensive guidance and simpler explanation again for a slightly complicated III experiments can be understood by students.

C. Effectiveness of Learning Devices

The effectiveness of learning device can be obtained from science process skill and student responses.

1)   Science Process Skills (SPS)

Pretest and posttest results of science process skills are analyzed by qualitative descriptive analysis by calculating the average pretest and posttest values, then the mean values are used to calculate the normalized N-gain score. Normalized N-gain scores were used to determine the category of students' science skill skills between before and after learning using inquiry learning models.

The average score of N-gain obtained by class XI MIA-1 is 0.65 - 0.94 in medium to high category (Hake, 1999). The average score of N-gain class XI MIA-2 is 0.60 - 0.95 in the medium to high category (Hake, 1999). The average score of N-gain class XI MIA-6 is 0.60 - 0.94 is high category (Hake, 1999). The three classes had a medium-high N-gain score because at the time of the study the three classes were very active and enthusiastic in learning. The results of per indicator can be seen in Figure 7, Figure 8, and Figure 9.
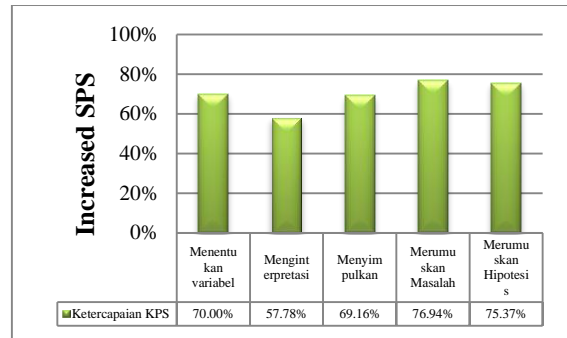

Figure 7. Results of the implementation of physics learning device class X I MIA- 1
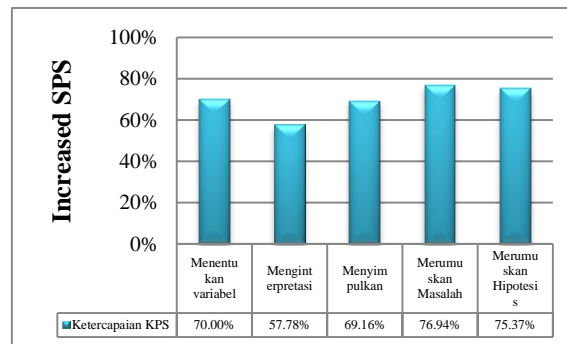

Figure 8.   The results of the implementation of physics learning device class X I MIA- 2
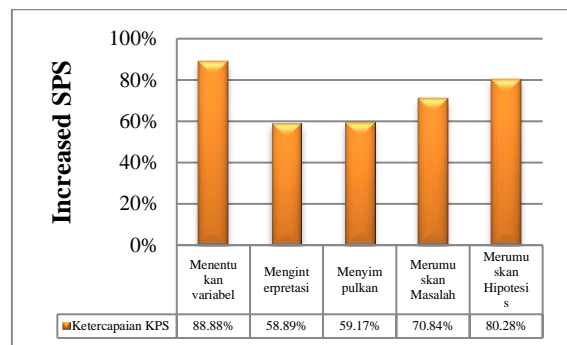

Figure 9 .   The results of the implementation of physics learning device class XI MIA- 6

Percentage of science process skill achievement when based on science process skill indicator in each class hence shows the increase of significant progress. The increased includes determining variable by 70%, 70%, and 88.88%,, interpreting reachability by 57.78%, 57.78%, and 58.89%, concluding by 69.16%, 69.16%, and 59.17%, formulating problems by 76.94%, 76.94%, and 70.84%, formulating hypothesis by 75.37%, 75.37%, and 80.28% .

Compared with the results of the experiment I the percentage of science process skills in class XI MIA-5, XI MIA-4, and XI MIA-3 in determining variable is 66.66%, 75.55%, and 86.67% interpreting by 75.55%, 66.67%, and 64.44%, concluding

68.33%, 70%, and 70%, formulating problems 67.77%, 83.33%, and 85.56%, formulating hypothesis of 75.55% , 80%, and 84%. Based on both trial result and trial II result, there is a significant increase in the achievement of science process skill in every indicator this is evidenced by the value comparison exceeding 50%.

The improvement of science process skills in each class is due to the use of inquiry learning model can be used as a vehicle to help students practice the science process skills. At the stage of formulating problem, formulating hypotheses, identifying variables, designing experiments, conducting experiments, analyzing data, and making conclusions with teachers have grouped students into learning groups. This grouping can make students more active and courageous in expressing their opinions.

This is in accordance with the social constructivism theory of Vigotsky which states that students learn through interaction with more capable adults and peers. One of the stages that make students very enthusiastic in learning is the stage of doing this experiment because physics teachers never has never conducted an experiments before, usually only ordinary teaching or monotonous learning. The teacher's learning is in contrast to the modern psychology that says "In teaching children to get fish, let not the teacher give the fish, simply gives the hook" This metaphor actually has the meaning that the student must be self-active the only gives a reference or tool (Sardiman, 2011).

Therefore, the task of educators to guide and provide conditions so that students can develop talent and potential. According to Piaget, children will think when he does something. Without him doing something means the child is not thinking (Sardiman, 2011). Abruscato (1992), states "The discoveries that scientist make come from their ability to use a group of very different but very important skills. These skills are formality known as "the science process skills". These skills are not only important for scientist; they are also important skills that we can use to develop a classroomlearning environment that has discovery learning as an important focus".

According to Abruscato, the discoveries that make science come from the ability to use a group of skills that are very different, but very important. This skill is known as science process skill. These skills are not only important to scientists, they are important for developing a classroom environment in learning, where discovery is the focus of learning.

The result of normality test using Kolmogorov Smirno test as shown in Table 1.

Table 1. Normality test results

Sample	α	Sig	Information
Class X I - 1	0,05	0, 07 1	Normal
Class X I - 2	0,05	0, 099	Normal
Class X I - 6	0,05	0,0 99	Normal

Based on hypothesis test of H0 and H1, sig> α then H0 is accepted, data come from normal distributed population. It means that the condition of the sample taken is similar to the actual population.

Homogeneity test results using Levene test is shown in Table 2.

Table 2. homogenity test results

Sample	α	Sig	Information
Class X I - 1	0,05	0, 671	Homogen
Class X I - 2	0,05	0, 671	Homogen
Class X I - 6	0,05	0, 671	Homogen

Based on hypothesis test of H0 and H1, it is obtained that sig> α then H0 is accepted, it means the data comes from homogenous population variance. It shows that all students have the same knowledge ability at the beginning of learning.

The result of paired t test as shown in Table 3.

Table 3. paired t-test results

Sample	t	df	α	sig
Class XI- 1	-35.936	2 9	0,05	0.000
Class XI- 2	-30.864	29	0,05	0.000
Class XI- 6	-33.169	29	0,05	0.000

Based on hypothesis test of H0 and H1, sig <α then H0 is rejected, mean of pretest result and posttest result in significant difference (Sugiyono, 2014). It indicates that pretest data before treatment and posttest data after treatment shows that learning with inquiry model has significant influence in training students' skilled process of science. The results of this study are supported by the previous studies results (Prahani, et al., 2015; Prahani et al., 2016; Prahani, et al., 2018) that the learning materials and learning models of quality and feasible (meet the valid, practical, and effective aspects) can improve student learning outcomes.

2) Student Response

Information on student responses to teaching and learning activities was obtained from questionnaires given to students after three lessons. The result of students' responses shows that teacher's guidance when working on the Student Worksheet during the activity learning reached the highest score by 100%. Students can understand worksheet and how to teach because researchers design learning from the simple to the complex. This is in line with Ivor K. Davies' opinion (in Suyono, 2011) that one of the roles and functions of the teacher is as a culminate, the teacher designs learning from beginning to end from simple to complex, the culmination of success in the learning process.

COCLUSION

Based on the results of the analysis, discussion, and discussion, learning of physics can train students by using student inquiry model that has fulfilled the criteria of validity, practicality and effectiveness so that it is feasible to be used to train students' science process skills on material elasticity.

Based on the author's experience during the research, the authors suggest the study in this paper is an early step to be continued in more in-depth research for the improvement of science and technology in the future, especially in the field of education.

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